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APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

DYNAMIC VSI DISPLAY

Inventors: Ted Naimer, Sam Hyatt, Jim Brannen, Tom Lawrence

Assignee: Universal Avionics Systems Corporation

Attorneys: Standley & Gilcrest LLP
Attn: Jeffrey S. Standley
495 Metro Place South
Suite 210
Dublin, Ohio 43017
Telephone: (614) 792-5555
Facsimile: (614) 792-5536

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BACKGROUND AND SUMMARY OF THE INVENTION

[0001] Situational awareness refers to the degree of accuracy by which one's perception of his current environment mirrors reality. With regard to the operation of an aircraft, situational awareness relates to a pilot's perception of what is happening to the aircraft within the four dimensions of space and time. Situational awareness also relates to the pilot's comprehension of a present situation and a projection of the status of the aircraft into the near future.

[0002] During the operation of an aircraft, multiple operational parameters and systems must be monitored simultaneously, including the airspeed, attitude, engines, fuel management, navigation indicators, and weather radar. Many of these operational parameters and systems on the aircraft must be supervised by a pilot reacting to subtle changes in the alignment of needles on gauges or of pictorial displays on screens.

[0003] The present invention relates to improved displays of aircraft operation data that increase the situational awareness of a pilot and flight crew. The present application claims new displays or presentations of aircraft data. The displays of the present invention employ commercially available systems that may be used without modification to supply the necessary signals to operate the displays of the present invention. The present invention relates to improved displays of aircraft operation data that increase the situational awareness of a pilot and flight crew. More particularly, the displays of the present invention include a vertical speed indicator (VSI) display.

[0004] Traffic alert and Collision Avoidance System (TCAS) is a system for detecting and tracking other aircraft approaching the vicinity of a TCAS-equipped aircraft. By continuous interrogation of the transponders of the approaching aircraft, the TCAS system estimates and updates the flight paths of the approaching aircraft relative to the TCAS-equipped aircraft. Through the projection of the approaching flight paths of other planes relative to the position and path of the TCAS-equipped aircraft, the TCAS system will determine if an approaching aircraft is a possible collision hazard. If a collision hazard exists according to TCAS, the system will issue visual and auditory advisories, also known as resolution advisories, to the crew for appropriate vertical avoidance maneuvers.

[0005] The present invention includes the display of "fly-to" commands on a vertical speed indicator during a TCAS traffic or resolution advisory condition. The present invention typically includes a representation of an arc or semicircular depiction of a vertical speed indicator scale. The present invention may also comprise a marker, such as a pointer, or a viewing window having a digital numeric display showing the current vertical speed of the TCAS-equipped aircraft. The display of the present invention may also comprise indices or graduations along the arc or semicircle that are representative of typical analog-type displays. For example, a display of the present invention may have a vertical speed scale showing a continuous range of indices matching the typical markings of analog scales such as 0 (zero), +/-500, +/-1000, +/-1500, +/-2000, +/-2500, +/-3000, +/-4000, +/-5000, and +/-6000 feet per minute. It is also possible for examples of the present invention to arrange said indices in a nonlinear fashion around the scale. Also typical of an example of the present invention

is the showing of no-fly segments around the periphery of the VSI scale in a red color, and conversely, fly-to segments may be shown in a green color. In addition, examples of the present invention may include other uses of color, particularly the red color as an indicator of no-fly segments and green at fly-to segments, on elements such as the marker, the digital display or other elements in a viewing window, or on the periphery of the VSI scale. It is also possible for examples of the present invention to include a change in size, in particular an enlargement of the VSI display on a typical viewing device, in order to provide additional visual cues to a flight crew in order to indicate determinations of TCAS or resolution advisory flight conditions for an aircraft.

[0006] Examples of the present invention may also include representations of fractional sections of a VSI scale. The fractional section may be shown either on a semicircle, as a fixed arc, or along a portion of an ellipse. The particular portion of a VSI scale shown with an example of the present invention would typically present the current vertical speed of an aircraft on the VSI scale bounded equidistant by the range of the values for vertical speed shown on that portion of the VSI scale. This type of display may be provided by linear or nonlinear distributions of the indices for reading along the VSI scale. Conversely, the VSI scale may by bounded on at least one end by an upper limit, such as –6000 or +6000 feet per minute. To assist the flight crew in the readability of the display of the present invention, on the occasion wherein the actual VSI was at or above an upper (or lower) limit or extreme of the VSI scale, the VSI scale may at least provide an additional indicia marking such as the 0 (zero) mark to provide a frame of reference. It is also possible for an indicator such as the vertical speed marker

having a numeric display to show actual vertical speed figures beyond the range of the displayed VSI scale, for example +/-9999 feet per minute.

[0007] In addition to the features mentioned above, objects and advantages of the present invention will be readily apparent upon a reading of the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Novel features and advantages of the present invention, in addition to those mentioned above, will become apparent to those skilled in the art from a reading of the following detailed description in conjunction with the accompanying drawings wherein similar reference characters refer to similar parts and in which:

[0009] **Figure 1** illustrates example embodiments of the dynamic VSI display of the present invention;

[0010] **Figure 2** illustrates an example embodiment of the VSI display of the present invention; and

[0011] **Figure 3** illustrates example embodiments of VSI displays of the present invention.

DETAILED DESCRIPTION OF THE EXAMPLE PREFERRED EMBODIMENTS

[0012] The example embodiments herein described are not intended to be exhaustive or to limit the invention to the precise forms disclosed. They are chosen and described to explain the principles of the invention and the application of the method to practical uses so that others skilled in the art may practice the invention.

[0013] The Primary Flight Display (PFD) utilized in the example embodiments of the present invention is a dynamic, color display of all of the parameters necessary for flight path control. A typical PFD provides data related to an aircraft in flight including heading, airspeed, altitude, attitude, and vertical speed.

[0014] As can be noted in **Figures 1 - 3** of the example embodiments of the present invention, the object of the present invention is to provide a display of a vertical speed indicator (VSI).

[0015] **Figure 1** illustrates an example embodiment of a TCAS VSI display of the present invention. As shown in **Figure 1**, a portion of a PFD display **10** is shown with the TCAS VSI display **20** overlying a portion of adjacent depictions of flight information **30**. In this example embodiment of the present invention, an enlarged TCAS VSI display **20** overlying a portion of adjacent depictions of flight information **30** during TCAS or resolution advisory flight conditions is to be contrasted with a typical PFD display of a VSI during non-TCAS traffic or resolution advisory flight conditions. The enlarged TCAS VSI display **20** of the present invention allows a flight crew to better view flight instructions that are intended to avoid collisions with approaching aircraft. In contrast, during non-TCAS traffic, the VSI display would typically be sized to a complementary fit on the PFD and provide VSI information to the flight crew.

[0016] As shown in **Figure 1**, the TCAS VSI display **20** example of the present invention shows a full range depiction of a VSI scale **40** on a contrasting background **50**. The VSI scale **40** is shown with graduations **110** along its arc to denote indices for units of measurement of vertical speed. In this example, the full range depiction of the VSI scale **40** is +/- 6,000 feet per minute. In other embodiments of the present

invention, a full range depiction of a VSI scale can be increased or deceased as desired for the aircraft application. Typical ranges for the scale of vertical speed would be +/- 2,000, +/- 3,000, and +/- 4,000 feet per minute. The range may also be represented in metric measurements and for different time intervals, for example the range of vertical speed scale may shown in units comprising meters (for distance) or seconds (for time).

[0017] **Figure 1** also shows an example depiction of a vertical speed marker **70** as an arrow. The vertical speed marker **70** of the present invention shows the current vertical speed of the aircraft on the VSI scale **40**. Also shown is an example viewing window **80** displaying a numeric display **90** of the current vertical speed of the aircraft.

[0018] Along the periphery of the VSI scale **40** are TCAS resolution advisory indicators **100**. The TCAS indicators on the VSI are typically highlighted with a green color to indicate vertical speeds that a pilot is instructed to actively fly-to or maneuver the aircraft to satisfy a resolution advisory and to achieve safe separation from an approaching aircraft. In contrast the TCAS indicators on the VSI are typically highlighted with a red color to indicate vertical speeds that must be avoided as no-fly segments. Although not shown in color on **Figure 1**, the example embodiment is shaded to indicate the typical usage of a red arc **120** along at least a portion of the periphery of the VSI scale **40** to indicate a no-fly segment and the typical usage of a green arc **130** along at least a portion of the periphery of the VSI scale **40** to indicate a fly-to segment.

[0019] **Figure 2** illustrates example embodiments of the TCAS VSI display of the present invention. As shown at **140**, the digital display of vertical speed **150** and pointer **160** are shown in a shading to indicate an example a red-colored display when the

current vertical speed of an aircraft is within a no-fly segment **170** of the TCAS resolution advisory indicators. In contrast, as shown at **180**, the digital display of vertical speed **190** and pointer **200** are shown in a shading to indicate an example a green-colored display when the current vertical speed of an aircraft is within a fly-to segment **210** of the TCAS resolution advisory indicators.

[0020] **Figure 3** at **300** illustrates an example embodiment of a VSI display of the present invention. As shown at **300**, a fractional section of a VSI scale **1** is shown with a vertical speed indicator marker **2**, in this example shown as an arrow, showing the current vertical speed of the aircraft on the VSI scale **1**. As shown on **Figure 3** from the ranges depicted on the VSI scales at **500** and **600** at **3** and **4**, respectively, it is clearly shown that examples of the present invention may display non-linear scales for vertical speed. In addition, the VSI scales at **3** and **4** are shown as being elliptically shaped.

[0021] Also shown at **300** is a vertical speed bug **5** that may be activated and displayed on the inside edge of the VSI scale **1**. When selected for viewing or adjustment, the speed bug **5** may appear as a chevron pointing at the selected vertical speed as shown at **6**. In addition a digital value **7** for the selected vertical speed may appear on the display in a viewing window **8**. The digital value **7** may be freely selected or adjusted in stepped values (for example in fifty feet increments). In addition, an up or down arrow may appear as the first character **9** in the viewing window **8** to provide a visual cue for selecting a vertical speed value. In an example embodiment, the viewing window **8** containing the digital value **7** and the speed bug **5** may be visible only while the bug is being set and for a few seconds after it has stopped changing. The window **8**, digital value **7**, and the speed bug **5** may then be removed to declutter the information

shown on the display. In the event that the vertical speed bug **5** would be outside of the range of values displayed on the VSI scale **1**, half of the speed bug **55**, as shown at **500** or at **600**, is parked on the VSI scale **1** at the edge of the display limit. The speed bug **55** would resume its normal shape (i.e., as shown at **5**) and position when it may be displayed within the range of the display of the VSI scale **1**.

[0022] Having shown and described example embodiments of the present invention, those skilled in the art will realize that many variations and modifications may be made to affect the described invention and still be within the scope of the claimed invention. Thus, many of the elements indicated above may be altered or replaced by different elements which will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.